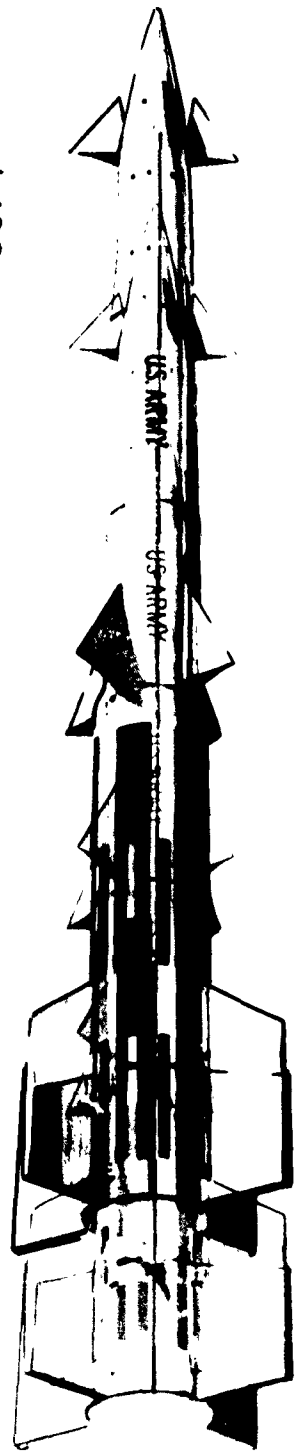

BALLISTIC CAMERA SYNCHRONIZATION & CONTROL SYSTEM

CONTRACT NUMBER DA 30-069-ORD-3291

Progress Report No. 8

LINK DIVISION
GENERAL PRECISION, INC.

AD ____________________ Accession No. __________ UNCLASSIFIED

Link Division, General Precision, Inc., Palo Alto, Calif.
BALLISTIC CAMERA SYNCHRONIZATION AND CONTROL SYSTEM Progress Report No. 8 (November 1, 1961 to November 30, 1961)(Unclassified)

Ballistic Camera
Synchronization Optical
Tracking System Design

15 pages and 12 illustrations
Contract No. DA-30-069-ORD-3291
OMS 5210.11.13506.05.55
DCN 110.095.006.006.1
Ser. No. 06-61173
No Distribution Limitations
Report is Unclassified

The circuits for the Rotating Disc Shutter Opening Circuit, the Synchronization Detector Circuit, the Resolver Servo, and the Tape Decoding Matrix are discussed. The assignment of tape commands is also presented. A diagram of Capping Shutter Timing is included. The present status of the G-4 Averaging Circuit and Technical Exhibit C are discussed.

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BALLISTIC CAMERA SYNCHRONIZATION & CONTROL SYSTEM

Contract Number DA-30-069-ORD-3291

Progress Report No. 8

Link Division
General Precision, Inc.

December 15, 1961

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LIST OF ILLUSTRATIONS

FOREWORD

This progress report is submitted in accordance with Article I, paragraph c(1) of Contract No. DA-30-069-ORD-3291. This eighth report documents the period from 1 November 1961 to 30 November 1961.

SUMMARY

The circuits for the Rotating Disc Shutter Opening Circuit, the Synchronization Detector Circuit, the Resolver Servo, and the Tape Decoding Matrix are discussed. The assignment of tape commands is also presented. A diagram of Capping Shutter Timing is included. The present status of the G-4 Averaging Circuit and Technical Exhibit G are discussed.

1.0 Introduction

This is the eighth in a series of monthly reports covering the progress of the Ballistic Camera Synchronization and Control System. These reports will provide a technical record of the development program. The work completed in the previous month will be covered, and an outline given of the work to be done for the next reporting period. Major problems that arise will also be reported.

2.0 Present Program Status

At this time, all purchase part items that are required for Technical Exhibit B are on order. The delivery dates for these items vary from November, 1961 to the middle of January, 1962. Work has been started on the wiring of the units that were included in Technical Exhibit B. The Brush recorder was received in late November 1961 and is now installed and wired. The G-4 Averaging Circuit has been wired and some preliminary testing of the unit has been accomplished. The major items of the Camera Synchronization System are finished and tested, however, there has not been a system test. This is because the electrical enclosure is being wired to accommodate the units called out by Technical Exhibit B. All circuits that were called out in the original specification and in Technical Exhibit B have been engineered.

3.0 Tape Commands

Figure 1 is a list of the tape commands. It should be noted that all eight channels have been used. The first group, consisting of channels 1, 2, and 3, are reserved for controlling the Ballistic Camera Synchronization and Control System. The second group consists of channel 4 and is reserved for use by White Sands Missile Range. The third group is composed of channels 5, 6, 7, and 8. This group is arranged in a matrix to give 16 commands.

GROUP 1

	Function	Channels		
		1	2	3
1	UNASSIGNED			
2	Recorder Stop Shutter Close			X
3	Recorder Stop Shutter Open		X	
4	Recorder Start Shutter Close		X	X
5	Recorder Start Shutter Open	X		
6	Calibrate	X		X
7	Mission	X	X	
8	Tape Stop	X	X	X

GROUP 2
Channel 4 is Unassigned

GROUP 3

M	Function	Channels			
		5	6	7	8
1					
2					X
3				X	
4				X	X
5			X		
6			X		X
7			X	X	
8			X	X	X
9		X			
10		X			X
11		X		X	
12		X		X	X
13		X	X		
14		X	X		X
15		X	X	X	
16		X	X	X	X

X Denotes a hole

Figure 1 Tape Commands

4.0 Tape Decoding Matrix

Figure 2 is a block diagram of the tape decoding matrix. Group 1 consists of eight possible commands. These are the commands: no command, recorder stop capping shutter close, recorder stop capping shutter open, recorder start capping shutter close, recorder start capping shutter open, calibrate, mission, and tape stop. The recorder and capping shutter commands are combined so that simultaneous commands can be given to these two units. The combined recorder and capping shutter commands are fed into AND circuits to obtain the individual commands.

Group 2 (channel 4) is reserved for White Sands Missile Range. Command and Not Command are both available.

Group 3 is a matrix that develops sixteen signals from four channels. Only one of these commands is available at a time. The loading of all outputs, except the Not Command of channel four, is 7 unit loads. The Not Command of channel four is 6 unit loads.

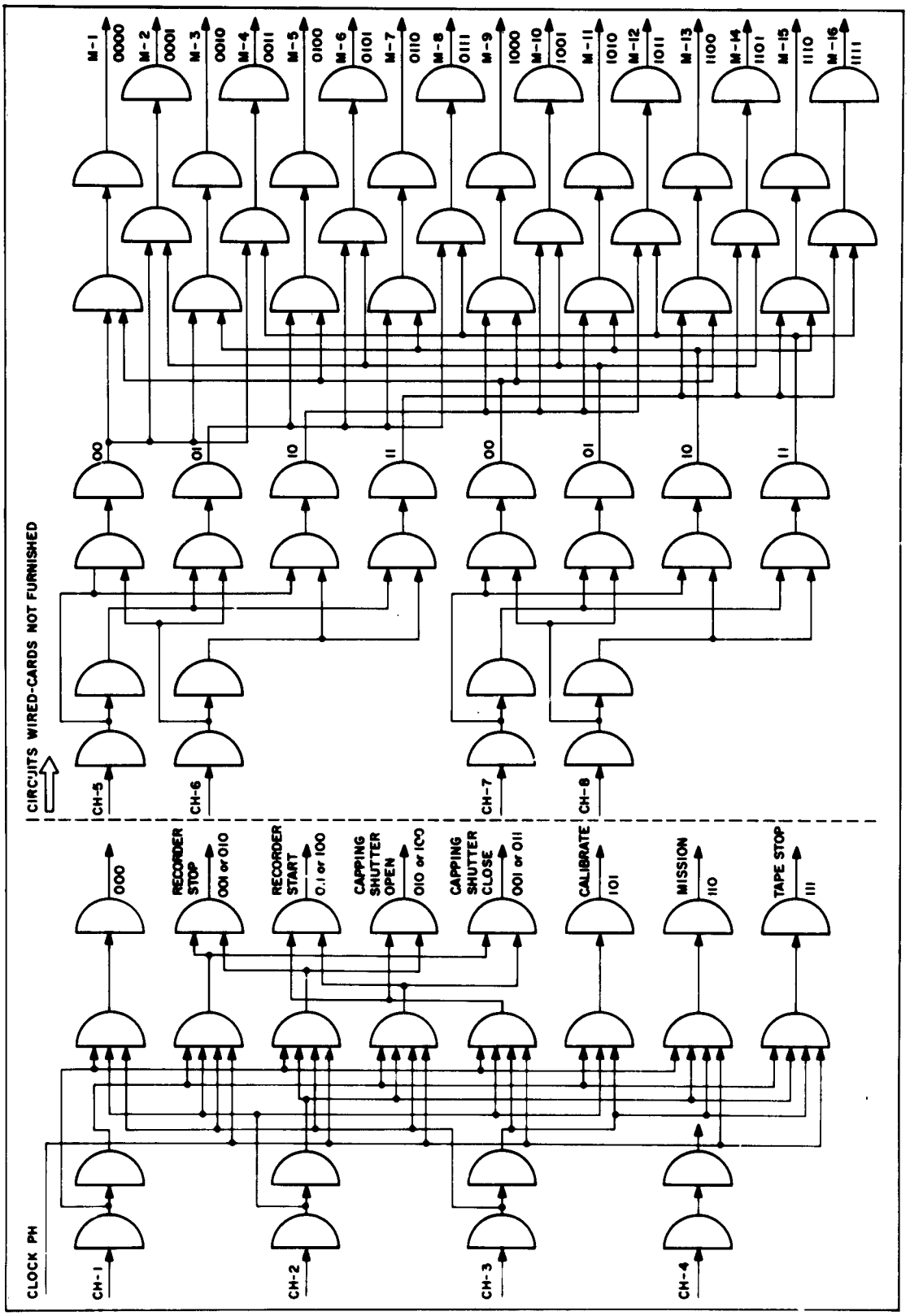


Figure 2 Tape Decoding Matrix

5.0 Rotating Disc Shutters Opening Circuit

The rotating disc shutters opening circuit removes the steady 500 cycle drive power from the camera motor. After the motor stops, a pulse train of two pulses per second is supplied to the camera motor. The exact length of the pulses is not known at this time. The pulse length can be varied in the field or set by Link when the pulse length is known. The exact pulse length is to be supplied by the camera manufacturer. Figure 3 is a diagram of the Rotating Disc Shutter Opening Circuit. It should be noted that there are two time delay relays in series – for this reason a failure of a time delay relay will not damage the camera. Zener diodes are on both sides of the switching relay to protect the amplifier and motor from switching transients.

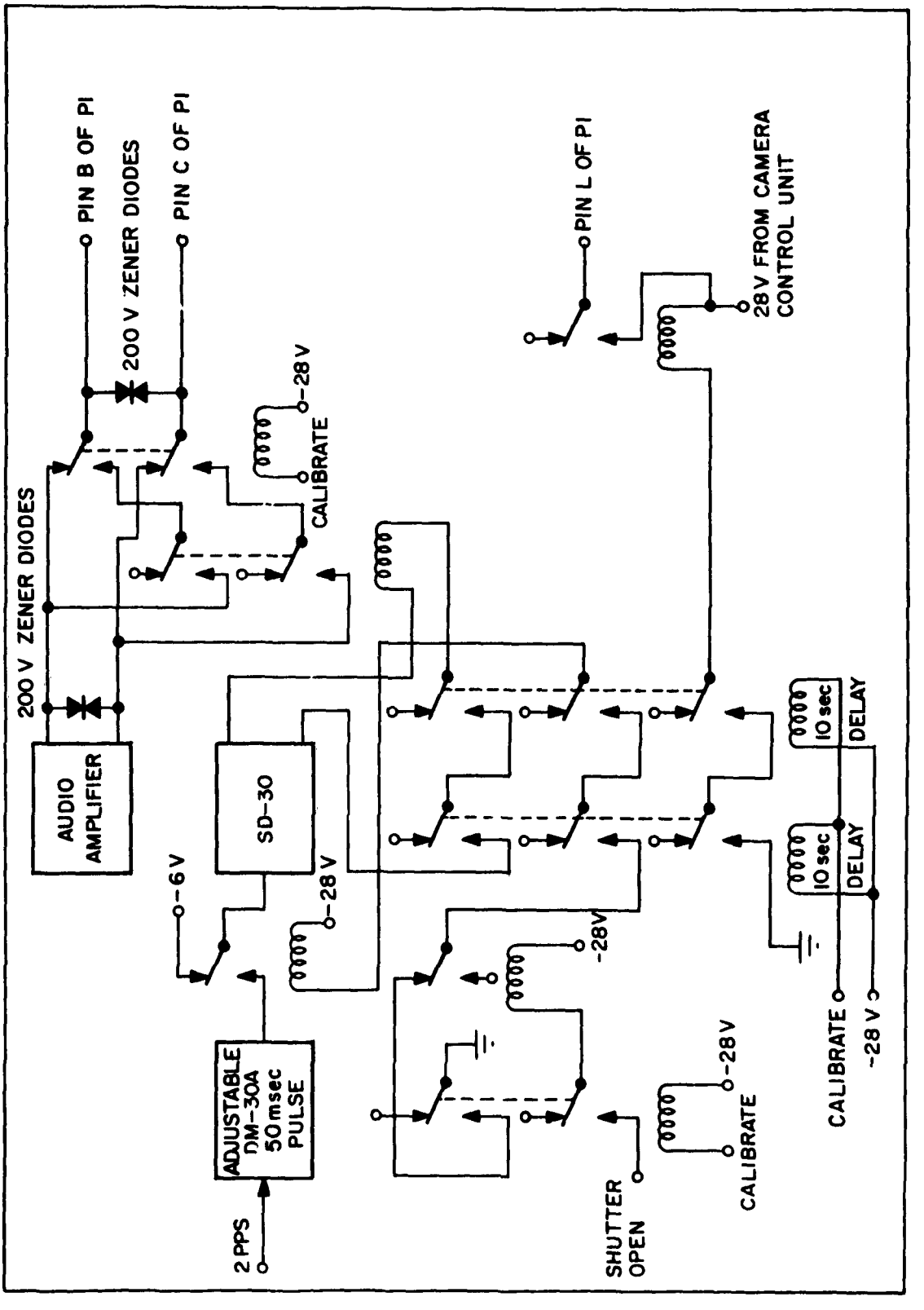


Figure 3 Rotating Disc Shutters Opening Circuit

6.0 Synchronization Detector Circuit

The Synchronization Detector Circuit detects the camera and shutter pulses and reshapes these pulses to standard 3C logic pulses. The signals required for the synchronization and visual display are also generated by the Synchronization Detector Circuit. This circuit also determines when the camera is in or out of synchronization. Fig .re 4 is a block diagram of the Synchronization Detector Circuit.

It has been stated previously that the camera pulse and shutter pulses are positive three volt pulses. To insure that noise is not a problem in the transmission of these pulses, the cables are terminated by fifty ohm resistors and Schmitt Triggers are used to detect the pulses. The Schmitt Triggers are set to trigger at one half the amplitude of the pulse. Any noise less than one and one-half volts will not trouble the system. The fast and slow pulses are stretched to 500 microseconds and are sent on to the Recorder. The camera pulse is required in three places and in three different kinds of signal. The first type of pulse is a standard 3C pulse which is required by the Automatic Synchronization System. The camera pulse is amplified to a standard 3C pulse and is also stretched to 500 microseconds and sent to the recorder.

The plus and minus one hundred microsecond pulses from the pulse generator are used to generate a gate that is two hundred microseconds wide and is centered on the in synchronization pulse. This gate pulse is used to determine when the camera is in or out of synchronization; and is also the pedestal pulse of the oscilloscope. When the camera pulse is out of synchronization, the alarm circuit is energized.

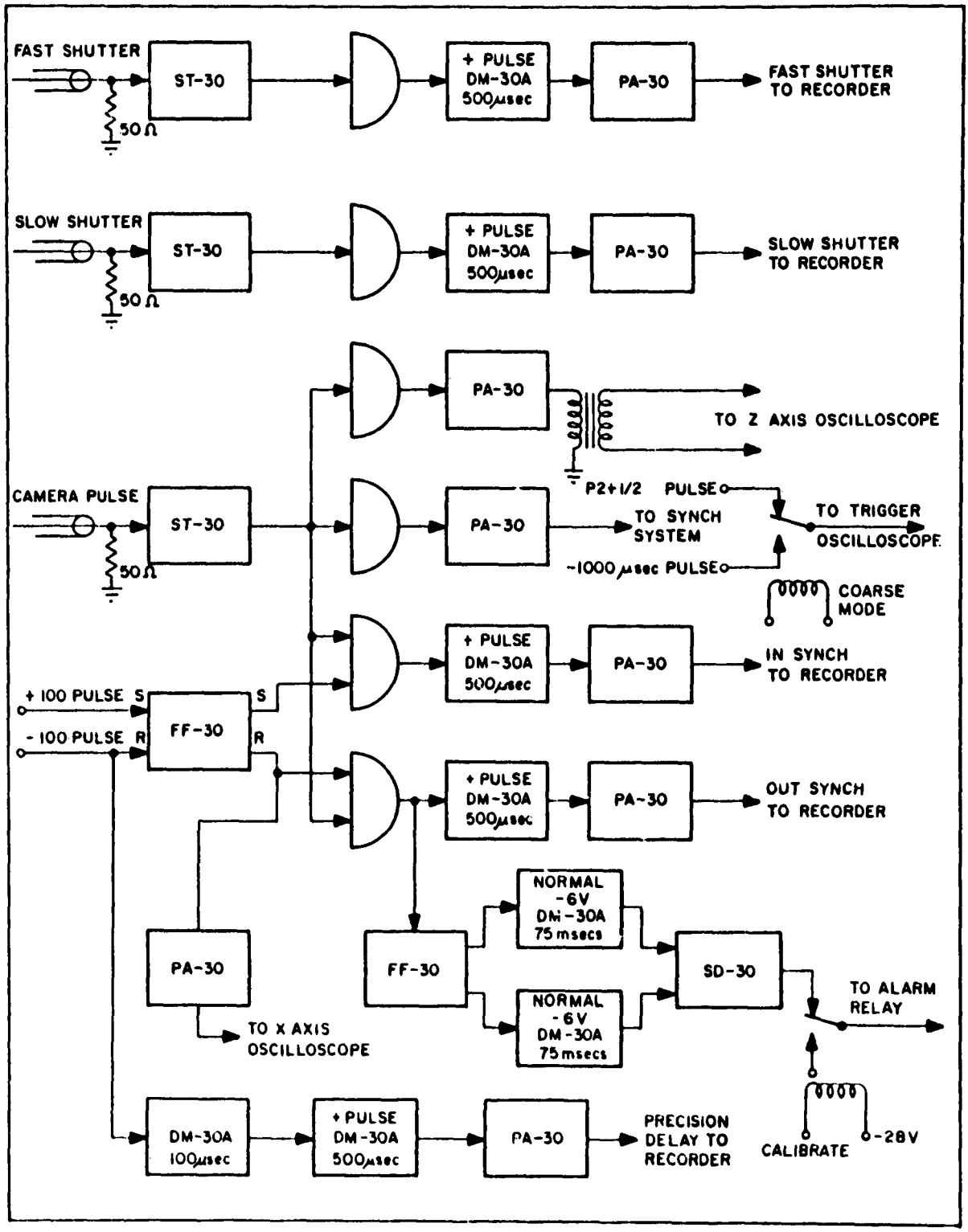
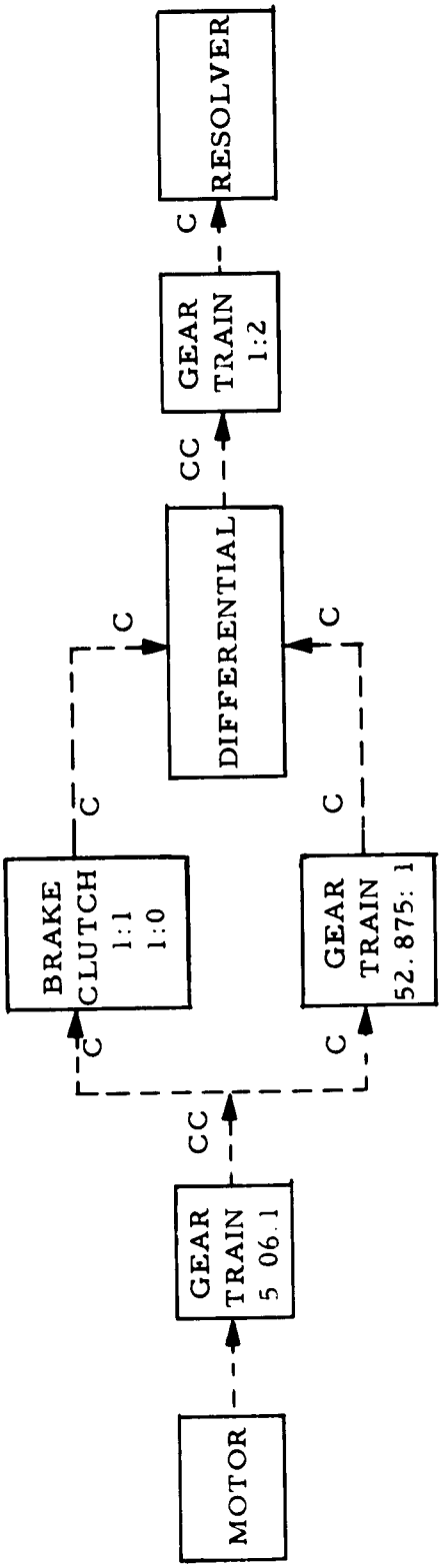


Figure 4 Synchronization Detector Circuit

7.0 Resolver Servo

This report includes a mechanical schematic and a picture of the resolver servo (Figures 5 and 6). During the coarse mode of operation, the gear reduction from the motor to the resolver is 4.966. The differential in this mode is being driven by the 1:52.875 step down gear train and the 1:1 brake clutch. The two inputs of the differential add. During the fine mode of operation, the clutch is open and the brake is on. Hence, the resolver is driven through the 1:52.875 gear train. This gives a gear reduction of 267.548 from the motor to the resolver.



HIGH SPEED GEAR RATIO 4.966:1
LOW SPEED GEAR RATIO 267.548:1
AT HIGH SPEED DIFFERENTIAL
ADDS THE TWO INPUTS. . . .

Figure 5 Two Speed Resolver Drive

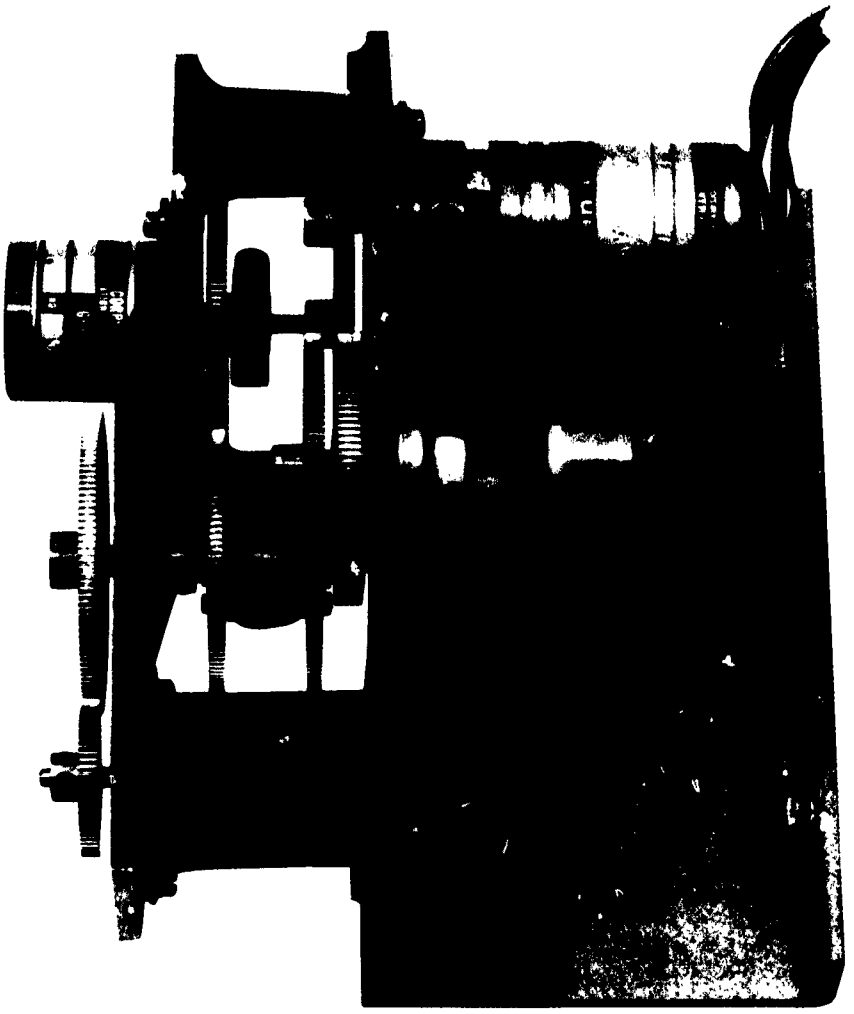


Figure 6 Picture of Two Speed Resolver Drive

8.0 Oscilloscope Presentation for Camera Shutter Pulses

Figure 7 is a drawing of the presentation of the two modes of operation for manual synchronization. During the coarse mode, the oscilloscope is triggered by the pulse train from the Pulse Generator that is displaced from the synchronization pulse train by one-half of a period. This allows the pedestal pulse to appear in the center of the oscilloscope. When the system is in the fine mode, the oscilloscope is triggered by the minus-one-thousand-microsecond pulse. The sweep rate for the fine mode is two hundred microseconds per centimeter. The pedestal is centered on the face of the oscilloscope at this sweep rate. The sweep rate for the coarse mode is 1/Shutter Rate. The triggering pulses are switched automatically. The sweep rates must be adjusted manually at the oscilloscope.

Preliminary testing indicates that sweep blanking gives better resolution than sweep brighting. Sweep blanking also has the advantage of not damaging the cathode ray tube when the spot appears in the same position for any length of time. Link requests White Sands Missile Range to forward their ideas on this problem.

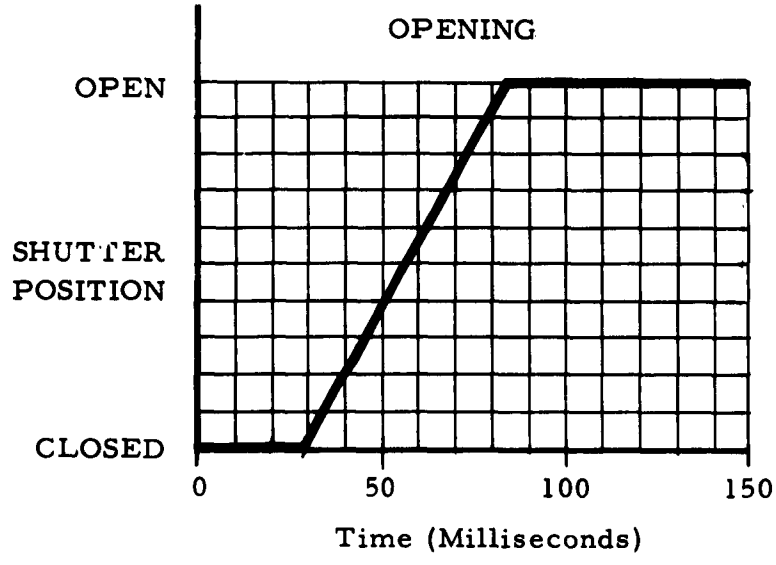
Oscilloscope Presentation Fine Mode
Camera in Synchronization

Oscilloscope Presentation Coarse Mode
Camera Pulse Leading the Timing Pulse by 1/4 of a Period

Figure 7 Oscilloscope Presentations for the Camera Shutter Pulses

9.0 Capping Shutter Timing

Figure 8 is a timing diagram of the capping shutter. This information is from the Fred C. Henson Co. Figure 9 is the timing diagram of the capping shutter imposed on the timing diagram of the rotating shutters. The frame rate is ten per second and the exposure time is 1/60 of a second. This is the worst case. The diagram shows that the capping will operate satisfactorily when triggered with the synchronization pulse. A larger safety factor can be obtained by triggering with the -1000 microsecond pulse. It is understood that the capping shutter will work at 2, 4, 5, and 10 frames per second.



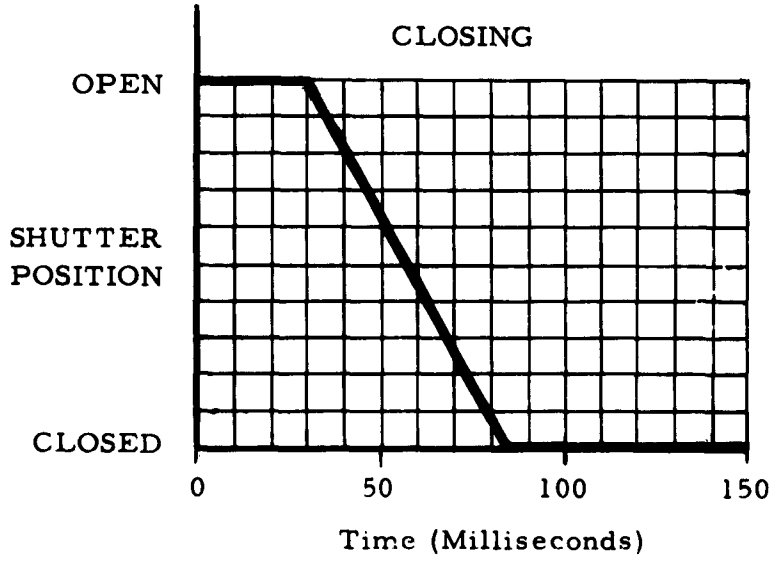


Figure 8 Timing Diagram of Capping Shutter

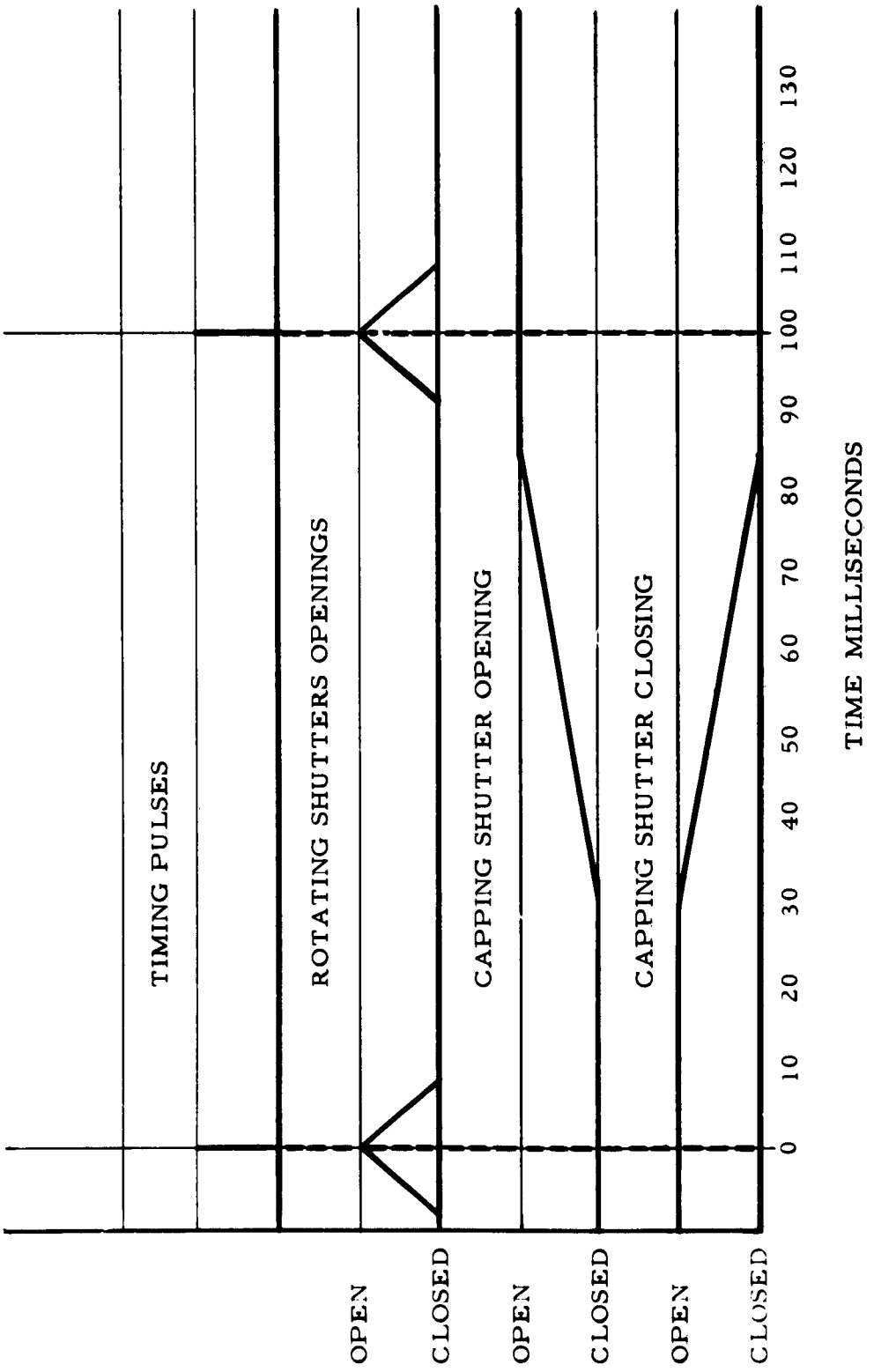


Figure 9 Camera Timing Diagram for 10 Frames per Second and an Exposure of 1/60 of a Second

10.0 G-4 Averaging Circuit

The G-4 Averaging Circuit has been assembled and some preliminary testing has been done. The G-4 Averaging Circuit will lock onto a non-jittering pulse within 48 seconds and stay locked on within 4 clock pulses. Since the G-4 averaging circuit design is based upon a statistical representation of the G-4 pulse train, a complete test will not be possible until the G-4 Averaging Circuit is driven with a G-4 pulse train. Work will be continued to determine if the 4 pulse error is a design limitation or a peculiarity of the circuit. With a jittering pulse train, the number of pulses prevented from flowing into the storage unit should equal the number of extra pulses flowing into the storage unit. Hence, the errors should cancel.

11.0 Technical Exhibit C

Link Palo Alto has received a notification from N. Y. Ordnance stating that Exhibit C is to be incorporated into the Contract in the near future. The Exhibit leaves several problems unresolved. It recognizes that many details cannot be clarified exactly until after Exhibit C is added as a contractual requirement.

Accordingly, we have had several phone conversations, and visits to WSMR by technical, as well as liaison personnel, to minimize the issues which are not yet specified. The following data represent our current understanding of Technical Exhibit C.

A 3000 VA Sola Line Regulator and the associated equipment (circuit breaker, terminal board, indicating lights, wiring, and front panel) will be installed in the second dual electronic enclosure. The installation will be similar to the kind of installation chosen for the first dual electronic enclosure. The two 3000 VA Sola Regulators will be fed by separate cables and there will be no interlocks between the two regulators.

Figure 10 is a diagram showing all of the controls, and their locations, of the Ballistic Camera Synchronization and Control System. The following is a list of all of the functions and locations of all of the controls.

Function	Astrodome Control	Indicator
Tape Reader	Run	Run & Stop
(Mission Mode, arms system; Calibrate Mode, starts tape reader)		
Camera Motor	On & Off	On & Off
Capping Shutter	Open & Close	Open & Close
Synchronization	–	In & Out
Capping Shutter	–	Operate & Lock

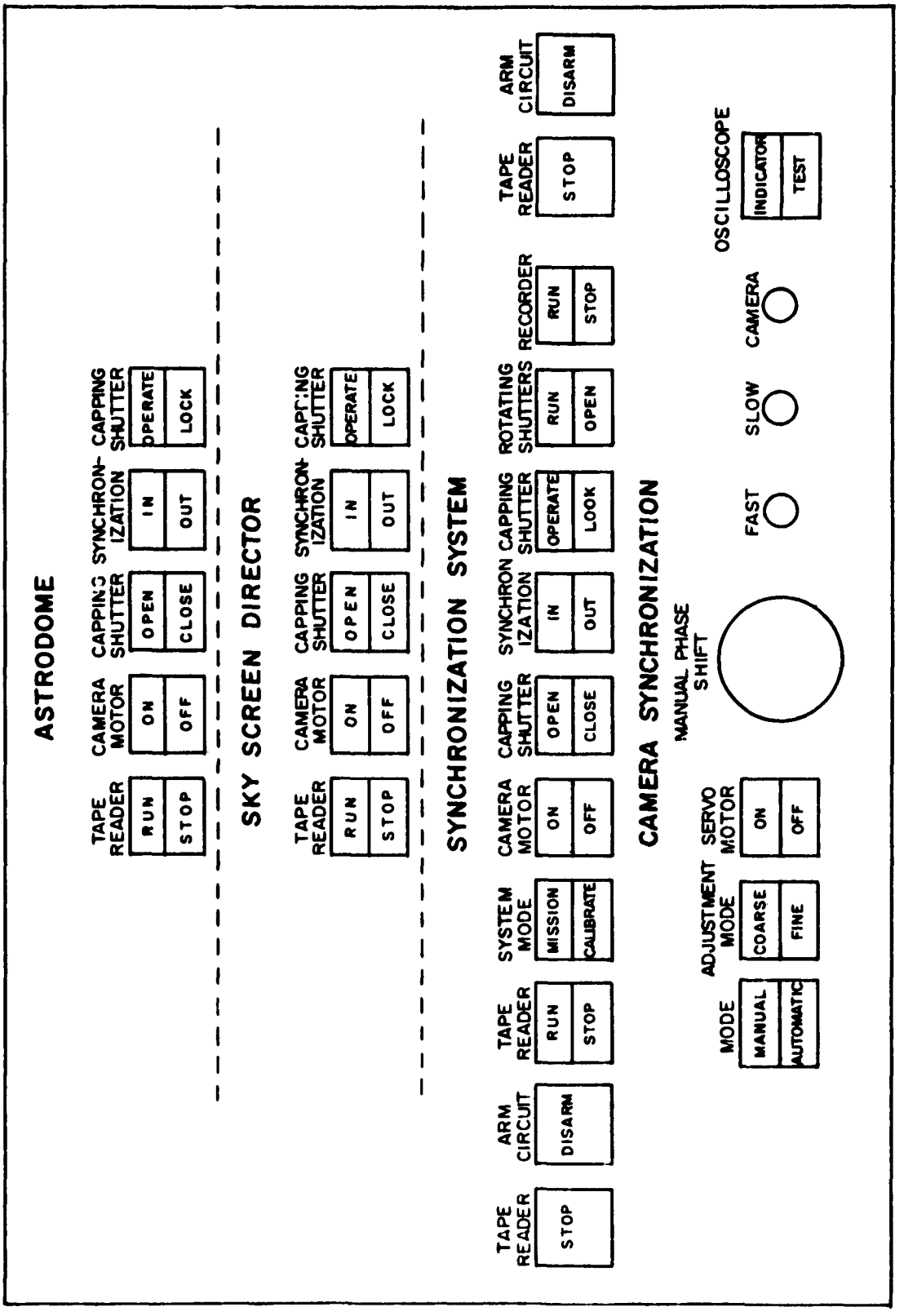


Figure 10 Ballistic Camera Synchronization & Control System Control Panels

Sky Screen Director

Function	Control	Indicator
Tape Reader	Run	Run & Stop
(Mission Mode, arms system; Calibrate Mode, starts tape Reader)		
Camera Motor	On & Off	On & Off
Capping Motor	Open & Close	Open & Close
Capping Shutter	–	In & Out
Capping Shutter	–	Operate & Lock

Synchronization System

Function	Control	Indicator
Tape Reader	Run	Run & Stop
(Mission Mode, arms system; Calibrate Mode, starts tape Reader)		
System Mode	Mission & Calibrate	Mission & Calibrate
Camera Motor	On & Off	On & Off
Capping Shutter	Open & Close	Open & Close
Synchronization	—	In & Out
Capping Shutter	Operator & Lock	Operator & Lock
Rotating Shutters	Run & Open	Run & Open
Recorder	Run & Stop	Run & Stop
Tape Reader (2 switches)	Stop when two switches are pressed simultaneously	Lights are on when tape reader is on.
Arm Circuit (2 switches)	Disarmed when two switches are pressed simultaneously.	Lights are on when system is armed.

Synchronization System (Continued)

Function	Control	Indicator
Camera Synchronization Mode	Manual & Automatic	Manual & Automatic
Camera Synchronization Adjustment Mode	Coarse & Fine	Coarse & Fine
Camera Synchronization Servo Motor	On & Off	On & Off
Camera Synchronization Manual Phase Shift	Camera Pulse Advance or Retard	—
Test Point	Fast Shutter	—
Test Point	Slow Shutter	—
Test Point	Camera Shutter	—
Oscilloscope	Indicator & Test	Indicator & Test

When the system is armed, or the tape is running, all of the controls in the astrodome and the sky screen director are inoperative. The following controls are inoperative in the synchronization system:

(1) camera motor on & off,
(2) capping shutter open & close,
(3) capping shutter lock,
(4) rotating shutters run & open, and
(5) recorder run & stop.

To disarm the system or stop the tape reader, two switches must be pressed simultaneously. This method of control should reduce to a minimum the danger of an operator stopping the tape reader during a mission. It is felt that the camera Synchronization Controls do not need to be interlocked. If White Sands Missile Range should desire that these controls be interlocked, then this will be accomplished.

White Sands Missile Range has suggested the use of serial operation for all multi-position switches. Link, Palo Alto, has pointed out to White Sands Missile Range that, although this method is the cheapest approach, a failure in any switch or connecting cable is catastrophic. A failure must be repaired before the system can operate. Parallel operation of the multi-position switch has the advantage of ignoring an open failure or removing a short failure and still have the remaining switch stay operative. Link, Palo Alto, will use serial operation unless directed to do otherwise.

Figure 11 is a drawing of the proposed mechanical layout of the Astrodome Control Panel. Since White Sands Missile Range has assigned 1-3/4 inches to this panel and the switches require over a one-inch cut out, ordinary panel construction cannot be used. To achieve the required stiffness and mechanical strength, the control panel will be made from a 1-3/4" x 1" U channel. The leads for the control panel will come in on a plug that will either be on a dangle or a bracket.

Link, Palo Alto, would appreciate the comments of White Sands Missile Range regarding the above description of technical Exhibit C.

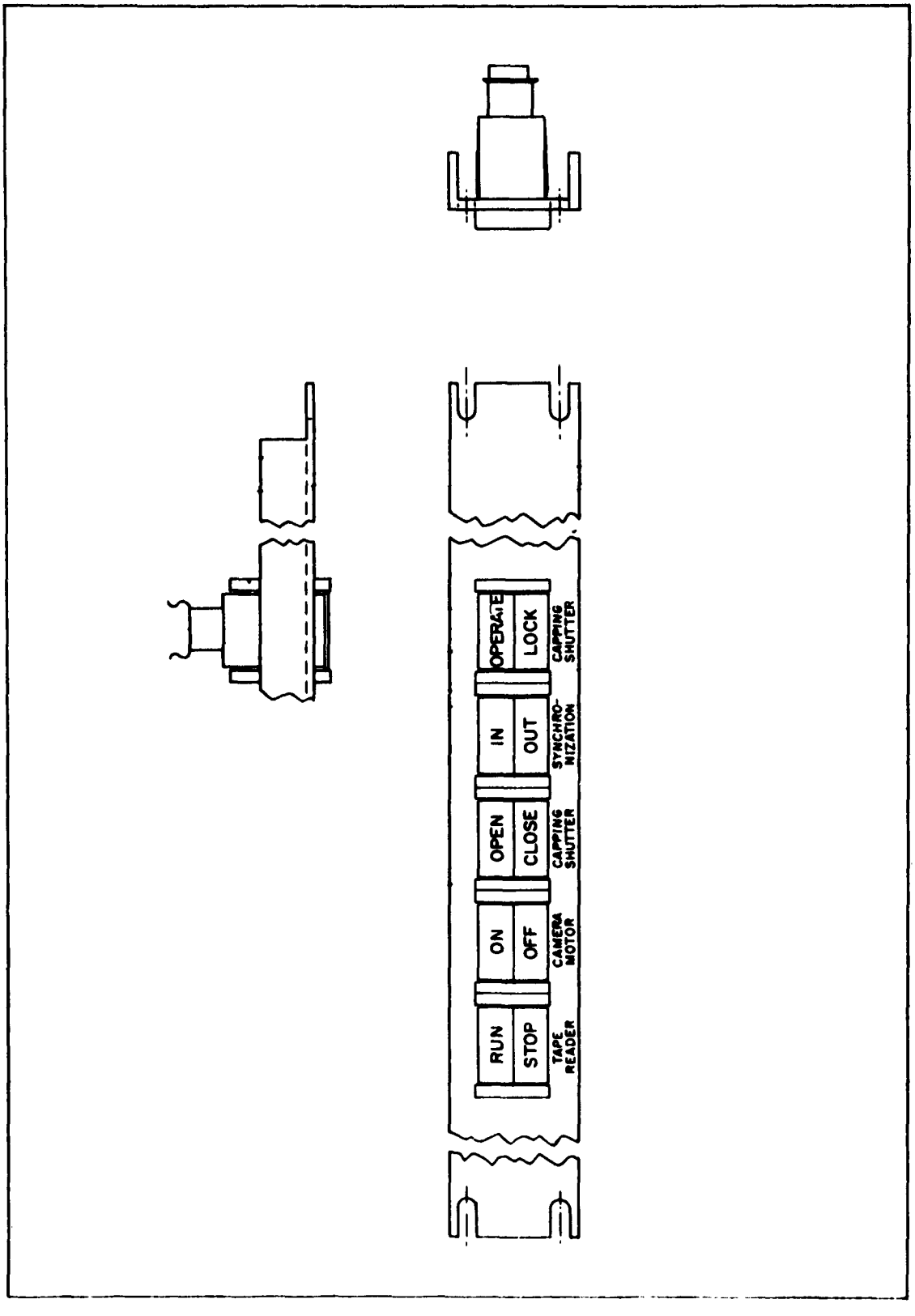


Figure 11 Remote Control Panel for the Ballistic Camera Synchronization & Control System

12.0 Program for the Subsequent Reporting Period

The program for the next Reporting Period will be to wire and install the units that are on order, as soon as they are received. If testing of the synchronization system can be scheduled to not interfere with wiring and installation, testing will be accomplished. Link, Palo Alto, is prepared to start work on Technical Exhibit C when approval is received.

13.0 Program Schedule

Enclosed with this report is a Line of Balance Delivery Schedule. This report is revised from those previously submitted. The revision results from the additional effort and delay incurred by incorporation of Exhibit B. The new delivery schedule is 2 March 1962. This has been discussed with WSMR personnel and we understand it is still within the time requirements of their overall planning.

F-2026-B

OBJECTIVE

($ THOUSANDS)

150
110
100
90
80
70
60
50
40
30
20
10

MAY | JUN | JUL | AUG | SEPT | OCT | NOV | DEC | JAN | FEB | MAR

1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11

SENSOR IDENTIFICATION

BALLISTIC CAMERA CRN 7350
(PROTO-TYPE UNIT ONLY)

1. Generation of Specifications
2. Start Procurement of Parts (1-unit)
3. Start System Design
4. Start Breadboard
5. Start Detail Design
6. Start Fab. & Assembly
7. Start Functional Tests
8. Complete System Design
9. Complete Ordering all Major Items
10. Complete Breadboard
11. Complete Drawing Required for Fabrication
12. Receive All Major Purchased Items
13. Complete Assembly
14. Start System Test
15. Ship to Test Lab for Environmental Tests
16. Complete All Drawings
17. Complete Environmental Tests
18. Ship to Customer
19. Ship First Unit 60 Days after Customer Acceptance of Proto-Type (Total of 7 Follow-On Units)

SYSTEM STUDY

BREADBOARD

DETAIL DESIGN

PROCUREMENT

FAB & ASSY

TEST & ADJUST

SHIP

1

SCHEDULE REVISED PER TECH. EXHIBIT 'B'

14 | 17 | 24 | 1 | 8 | 15

NOV | DEC

PROGRESS

LINE OF BALANCE CHART

7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59

BALLISTIC CAMERA (Revised 12-7-61)

PLAN **(Includes Tech. Exhibit B)**

LEGEND

- DELIVERY TO CUSTOMER
- CUSTOMER SUPPORT
- CUSTOMER ACTION
- VENDOR OR SUB-CONTRACT ACTION
- CONTRACTUAL ACTION
- PROCUREMENT ACTION
- FABRICATION OR ASSEMB
- PURCHASE PARTS
- COMPANY MADE PARTS
- REPORT TO CUSTOMER
- TEST OR INSPECT
- STUDY OR ANALYSIS
- SYSTEMS DESIGN OR DEVELOPMENT
- DETAIL DESIGN
- INTERNAL TRANSFER
- RAW MATERIAL

1 5 10 15 20 25 5 12 19 26 2 9 16 23 30

DEC JAN FEB MAR

WORKING PERIOD PRIOR TO SHIPMENT

GENERAL PRECISION, I